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Potential production of Hughlings Jackson's "parasitic consciousness" by physiologically-patterned weak transcerebral magnetic fields: QEEG and source localization

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ABSTRACT

Exotic experiences such as the sensing of another consciousness or the detachment of consciousness from the body are occasionally reported by individuals with partial seizures from a temporal lobe focus. The experiences display the characteristics of Hughlings Jackson's "parasitic consciousness". We have hypothesized that these experiences are encouraged by slight discrepancies in hemispheric activity that can be simulated by application of weak, physiologically-patterned magnetic fields across the cerebral hemispheres. Electroencephalographic and Low Resolution Electromagnetic Tomography (sLORETA) data revealed altered activity bands within specific regions within the cerebral cortices during these experiences. The clear changes in power of brain activity were discerned after consistent durations of exposure to specifically patterned weak magnetic fields. Millisecond range point durations were required. The technology may be useful to explore the subjective components associated with complex partial seizures.

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1. Introduction

The basic assumption of clinical neuroscience is that *all* experiences are generated by or strongly correlated with the patterns of neuronal activity and the state of the glial cell syncytium. Vivid ictal experiences reported by patients with partial-onset seizures are often associated with conspicuous and paroxysmal changes in brain activity. These subjective phenomena can be so personally meaningful that they influence the persons' beliefs and subsequent behaviors. One class of experiences is the feeling of a proximal sentient being or "sensed presence" [1–3]. Within an epileptic context, the prototypical experiences were succinctly described by Hughlings Jackson.

1.1. Historical progression of the relevance to epilepsy

The variants of sensed presences are remarkably persistent phenomena that have been frequently coupled with anomalies of temporal lobe functions. Huglings Jackson's [4] description of certain partial seizure experiences as a "parasitic consciousness" associated with nondominant (typically right) medial temporal lobe seizure activity anticipated the connection between these powerful experiences and transient brain function. Anne Harrington's [5] review indicates that the differential functions of the left and the right hemispheres with respect to "mystical experiences" have been clearly articulated since the late 19th century. Attribution of the experience of "the other" to increased right hemispheric activity relative to the left had been examined thoroughly within the limits of their measurements.

During the middle of the twentieth century, clinical observations by Dewhurst and Beard [6] and Slater and Beard [7] demonstrated the persistent association between "sensed presences" attributed to gods [8], ghosts, or other "entities" and partial seizures with a temporal lobe focus, particularly within the right hemisphere. These "temporal lobe transients" are sufficiently frequent that discrete electrical seizures within the right temporal region and the vivid experience of a sentient being or sensed presence can be measured occasionally within routine clinical settings [9,10] if a patient is sufficiently comfortable to report all experiences. The manner in which the experient interpreted the experience was strongly influenced by individual beliefs and cultural expectations.

Direct intracerebral stimulation by early neurosurgeons such as Walter Penfield or Vernon Mark demonstrated that "time distortions", déjà vu, sensed presences, and out-of-body "projections" could be

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elicited in some individuals. Usually, the most effective electrical stimulation was within the right temporal cortices or the mesiobasal subcortical structures such as the amygdala [11,12]. All of these experiences occurred within surgical settings.

Spontaneous occurrences such as the young woman with temporal lobe epilepsy who reported visualizing a small humanoid that followed her into her automobile [13] could reflect sensitivity to the setting and cognitive state. That context at the time of surgical stimulation affects the details and interpretation of the evoked experiences is well known [14,15] and has been considered a more intense form of ecphory [16]. It is defined as the interaction between the context and the ongoing neurocognitive experiences that eventually determines the details, themes, and attributes of the perception [17].

Technology within the last two decades has been particularly revealing about the sources of sensed presences. Functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and single positron emission computer tomography (SPECT) have shown specific activity within the temporal lobes or adjacent parietal connections [18] during protracted sensed presences [19]. This complements the occasional clinical case where slow-growing meningiomas over the right temporal lobe produced "the feeling of someone standing nearby" [20].

Blanke and his colleagues' [21,22] recent experimental results demonstrated that shadow persons and out-of-body experiences could be evoked by stimulation of the left and right parietotemporal junctions, respectively, which are powerful examples of how local electrical currents can produce experiences at one time attributed to spiritual or ethereal domains. From the perspective of Hughlings Jackson's observations, the sensed presence would be the intrusion of the "parasitic consciousness" from another space into that of the experient, while the out-of-body experience would be the consciousness of the experient perceived within the space of the "parasitic consciousness".

1.2. Noninvasive methodologies

Within the last 20 years, we [23–25] have developed a more noninvasive technology that does not require direct cerebral cortical stimulation or induction of large electric currents to investigate the subjective effects. Instead, weak (~1 μT), physiologically-patterned magnetic fields are applied from arrays of solenoids arranged around the subject's head or across the two hemispheres at the level of the temporoparietal plane [26]. There is clear evidence that these weak magnetic fields penetrate cerebral space without any discernible attenuation [27].

The intensities we have employed are within the ranges that affect several enzyme systems in vitro [28]. Recent biomolecular studies [29] have shown that the same field patterns and intensities by which the sensed presence and out-of-body experiences are generated influenced T-type calcium channels and correlative changes in molecular pathways such as slowing of proliferation of cancer cells within cultures. Experimentally-induced limbic epilepsy in rats by muscarinic agents increases the proportion of neuronal plasma membrane calcium channels to T-type forms that are strongly associated with burst firing [30]. The magnetic exposure effect for the cancer cell studies required between 15 and 30 min of exposure to emerge. Presentation of the optimal magnetic pattern in reverse order or only components of the pattern did not produce any significant changes in cellular responses.

The fields in our studies are usually applied for about 20 min to 30 min while the subject sits blindfolded in a quiet, darkened room (acoustic chamber). To distinguish the procedure from transcranial stimulation (TMS) whose symmetrical pulsed field strengths are about a million times stronger, the term *transcerebral stimulation* (TCS) has been employed. We had reasoned that the more the complex pattern of the applied fields approached the form of intrinsic cerebral patterns, the less the intensity required to produce subjective and electroencephalographic changes. The rationale was similar to strategically developing molecular structures of pharmacological agents to be congruent with neurotransmitters for receptor subtypes. For analgesic effects in rats, for example, exposures of only 30 min to appropriately patterned magnetic fields with intensities of only 1 μT were equivalent to a subcutaneous injection of ~5 mg/kg of morphine [31] mediated through μ opioid receptors.

1.3. Isolating optimal parameters in "non-epileptic" populations

Earlier experiments indicated that successive 5-minute sequences of different complex-patterned fields could entrain strip-chart-based EEG patterns [32]. The effect was conspicuous in healthy individuals with predictable patterns of cognitive experiences that presumably reflected sensitized temporal lobe functions as well as for individuals who sustained "mild" closed head injuries from mechanical impacts [33] without the suspension of consciousness. The latter population reports an unusually high incidence of sensed presences and a perceived loss of the previous "sense of self" following the injuries [34]. In fact, reports of a sensed presence and the feeling of the loss of the "self" are so common for patients who display quantitative neuropsychological deficits that these dual reports are almost predictive of cerebral injury. This population also showed a disproportionate increase of test scores suggesting hypofunction within the right prefrontal regions [35] as well as above normal incidences of partial seizure-like experiences [36].

One of our first experimental demonstrations that a "parasitic consciousness" beginning as a sensed presence and evolving into an "apparition" coupled with "shivers of fear" could be induced experimentally involved a middle-aged professional journalist [37]. During EEG measurement while a frequency-modulated field was applied with a slight increased (10%) intensity over the right hemisphere compared with the left, the subject began to experience left-sided subjective experiences that became dominated by "chills" and "shivers". Each of these periods was associated with fast paroxysmal electroencephalographic activity over the right temporal regions.

The experiences culminated in the experience of an apparitional and bright light (concurrent with a paroxysmal pattern often associated with limbic electrical seizures) that he identified as identical to the one he had experienced in a "haunted area" several years previously. Whether the experience was due to a "re-vivified" memory or direct elicitation does not change the importance of the observation that an experimentally-generated weak magnetic field produced both qualitatively conspicuous localized temporal lobe activity and the experience simultaneously.

To assess the subjective experiences associated with experimental exposures to the physiologically-patterned magnetic fields, we developed an exit questionnaire that contained essential experiences and indicators. Most of them are thematically similar to "complex partial epileptic-like subjective" (CPES) reports known to be associated with focal stimulation of the temporal lobes [38]. Although ongoing narratives are informative, the cerebral activation required for talking often interferes with the experiences associated with the applied fields. Even concentration upon the sensed presence alters the phenomena. For example [39], one subject who experienced a powerful sensed presence reported that the "presence" moved around her every time she "concentrated" on its location, a neurocognitive process that would have presumably altered the pattern of brain activity and, hence, the interference patterns generated by the applied magnetic fields.

1.4. Measurements of validity and reliability

Correlative validity for the questionnaire was supported by the increase in proportions of vestibular-related experiences of subjects

within the experimental setting when natural geomagnetic activity exceeded 20 nT. Mulligan et al. [40], replicating quantitative EEG (QEEG) results by Babayev and Allahverdiyeva [41], showed moderately strong correlations between geomagnetic activity and right frontal lobe activity. Experimental simulation [42] of the effect revealed a latency of about 10 min before the changes in cerebral power were significant. The approximately 10- to 15-min latencies before QEEG shifts become apparent and statistically significant during continuous, physiologically-patterned magnetic field application have been observed by several members of our research group using different devices for cerebral application.

Identification of experiencing a sensed presence was correlated from 0.78 to 0.86 with increased power (μV^2/Hz) within the theta range over the right parietal and frontal regions [43]. To discern if a history of experiences was related to specific temporal lobe activity, the Personal Philosophy Inventory (PPI) was developed [44]. Over the last approximately 30 years, about 2000 cases have been collected. Construct validity was supported by the moderate strength correlations between the proportion of items endorsed on the main temporal lobe scale during classroom settings and the proportion of alpha rhythms over the temporal lobes (compared with the occipital lobes), while a random subset of these participants sat within a comfortable darkened room between a week to several months later [45].

Reanalyses of 19 experiments, some of them conducted under blind or double-blind conditions, published over several years were completed by St-Pierre and Persinger [39]. Most of the subjects had volunteered for "relaxation" or "learning" studies so that expectation would be minimal. Approximately 80% of these subjects reported a sensed presence when a *slowing* frequency-modulated field was first applied continuously with a slightly right hemisphere bias for 30 min followed by the equalized bilateral application of an *accelerating* frequency-modulated (burst-firing) field for 1 s every 3 s for 30 min. A similar temporal order (slowing frequency modulation and bilateral accelerating frequency modulation presented for 15 min each) of field presentation over the right hemisphere increased the report of sensed presences [46]. Presenting the same field patterns in reverse order was not as effective.

1.5. Operational definition of Hughlings Jackson's conceptual model

The working hypothesis was that initial continuous stimulation over the right hemisphere followed by the intermittent bilateral stimulation would increase the probability of intrusion of right hemispheric processes into left hemispheric awareness [47]. The awareness or interpretation of this process would be experienced, in general, as some type of sensed presence. The general description is what Hughlings Jackson described as a "parasitic consciousness".

The validity for this explanation has been recently supported by quantitative EEG (QEEG) and subsequent coherence analyses with sLORETA (Low Resolution Electromagnetic Tomography). Vectorial analyses of individuals who reported the sensed presence showed coherence with the vector from the right temporal lobe to the left temporal lobe [48]. However, the details of what constitutes this "other" were affected by context, expectation, and personal belief. Interestingly, those who reported out-of-body experiences displayed a coherence pattern from the left hemisphere *into* the right hemisphere, particularly the right prefrontal region.

The apparent noncongruence with other studies involving much stronger MRI-like intensity fields [21,22] that showed the opposite effect could be accommodated if the strong stimulation utilized by Blanke's group inhibited the affected hemisphere, thus, allowing the nonaffected one to dominate experience. Nonlinear but intensity-dependent (rebound) effects are not unusual in homeostatic systems. For example, the difference between increased or decreased ACTH release during direct electrical stimulation of the limbic areas is dependent upon the durations (either <10 s or >10 s, respectively) of the afterdischarges following surgical stimulation [49].

In the St-Pierre and Persinger 2006 review, some of the experiments had involved groups who had been administered a norm-referenced interactive suggestibility scale (Hypnosis Induction Profile) developed by Spiegel and Spiegel [50]. Although some studies had shown that greater stimulation by these physiologically-patterned magnetic fields over the right hemisphere but not the left definitely increased suggestibility [51], this elevation was not associated with the occurrence of the sensed presence. The questionnaire scores for temporal lobe signs and experiences (that had been collected a few months before the subjects volunteered for the experiments) were moderately correlated with sensed presences in the darkened chamber if the patterned electromagnetic fields were present. The scores for the temporal lobe scale that reflected previous experiences with sensed presences were not correlated significantly with the report of a sensed presence in the experiment.

We have carefully assessed the experiences of individuals who are simply sitting in the chamber while blind-folded or those who have expected electromagnetic treatment but who have received no fields (sham condition) for both experimental and clinical treatments [52]. In addition to the qualitatively different profiles for the exit questionnaires, the subjects in the no-field conditions reported "boredom" very quickly. Perhaps, the most practical evidence that sham conditions are not effective is the conspicuous drop-out rates of depressed patients who had sustained closed head injuries who were randomly assigned to the sham control group versus the burst-firing treatment group for the standard six weeks of 1-h weekly treatments [23,53].

1.6. Importance of cerebral coupling temporal parameters of applied fields

For electromagnetic fields, the subtle temporal patterns or configurations strongly determine its function. Like the stereoisomers for molecular structures, the same EM frequency pattern that elicits the sensed presence does not produce these experiences when presented in the reversed order [38]. A similar effect was noted for analgesic effects for rats [30] and, just recently, for cell cultures [29]. Failure to accommodate the critical nature of point durations, which may be comparable with ignoring the subtle changes in the structure of a molecule, can produce different effects [54].

In our studies, the magnetic fields were created by transforming a series of numbers, each between 0 and 256, to a voltage between -5 V and $+5$ V ($127 = 0$ V). The point or "pixel" duration was either 1 ms or 3 ms. This value is the duration of each voltage that composes the pattern. In order to insure that precise timing was obtained, software must be embedded in machines more sophisticated than IBM 286 models. In addition, the program must be operated by DOS (Disk Operating System). Microsoft Windows, because of the background software operations and processes, can disrupt the point durations. Accurate and precise point durations are essential for producing the sensed presence [54,55]. Similar "temporal sensing" sensitivity for cells has been shown for frequency-modulated weak magnetic fields [56].

The critical importance of such precision was recently illustrated by Buckner [29] who found that the growth of melanoma cells markedly decreased by 50% when exposed for 1 h per day for five days to the slowing frequency-modulated field (the same one employed in the sensed presence protocol reported here) with point durations of 3 ms. The reversed pattern did not produce this effect; the growth did not differ from sham field controls. When point durations of 1 ms, 2 ms, 4 ms, or 5 ms for each of the numbers between 0 and 256 that comprised the field sequence were employed, there was no effect.

Confocal microscopy showed that influx of extracellular calcium ions coupled to a fluorescent tag was conspicuous when the field was generated by 3-ms point durations and was not obvious with the longer or shorter durations. The latency of the response was

between 15 and 30 min. In addition to the well-known Liboff solution that the resonance frequency for calcium within the static geomagnetic field is about "40 Hz", the popular electroencephalographic "substrate" for human consciousness, this ion and the associated T-type channels are involved with burst firing [57], emergence of limbic epilepsy [58], and the type of long-term potentiation (LTP) that can be markedly altered by LTP-patterned magnetic fields [59,60].

1.7. Rationale for present experiments

We decided to explore the generalizability of our previous protocols using slight variants of exposure durations and equipment in five experiments. The first experiment measured the subjective experiences of media personnel who were exposed to the sensed presence protocol and whose strip-chart EEG data were available. We assumed that they would be more representative of the general population than first year university students. The second experiment involved QEEG data for individuals who were exposed to either left or right side emphasized magnetic fields to discern differential hemispheric sensitivity.

Subjects in experiment 3 had been exposed to the sensed presence protocol so that the intracerebral coherence between those who experienced and who did not experience the sensed presence could be differentiated and visualized in discrete temporal increments. For experiment 4, individuals were exposed to a novel pattern that was custom designed to generate "chills" such as those associated with feeling of "something about to happen" or listening to music, while concurrent QEEG was completed. Care was taken to insure accommodation of polarity and wave-transform artifacts [61,62].

Designing an electromagnetic pattern that is compatible or "resonant" with the electrophysiological patterns of a "targeted" brain structure rather than attempting to "focus" a magnetic field is more feasible. Lagace et al. [63] demonstrated its effectiveness for the rat brain. Experiment 5 involved the effects of whole body exposure of the field patterns that were effective during transcerebral activation as well as a pattern extracted from the anomalous electroencephalographic pattern of a person known for an unusual ability to "experience" the memories of people near him that he attributes to the presence of "another consciousness" [64]. We assumed that the most naturalistic applied magnetic field pattern that would be required to produce Jackson's "parasitic consciousness" in the laboratory should be the digitized electroencephalographic field from the brain of a person who was experiencing this "other" at the time of the measurements.

2. Materials and methods

2.1. Participants

In experiment 1, a total of 31 participants who visited the laboratory over a 15-year period in order to document the experience for television programs primarily from Australia, England, the U.S.A., The Netherlands, and Canada were measured. About half the numbers were atheists or agnostics, while the remainder had experienced a near-death experience. In experiment 2, 11 subjects were between 18 and 25 years of age who volunteered for a relaxation study. In experiment 3, the QEEGs of 10 subjects (4 experienced the sensed presence and 6 did not) who had been exposed to the sensed presence protocol were involved. For experiments 4 and 5, there were a total of 10 and 6 subjects, respectively. Except for experiment 1, all the subjects were between 19 and 25 years of age. All protocols had been approved by the university's Research Ethics Board.

2.2. Materials and equipment

The modified motorcycle ("snowmobile") helmet employed in previous studies [25] was then placed onto the head over the standard P79 Grass system sensors (F7,F8; T3,T4; and O1,O2) for the film crews or the more recent 19-channel electrode cap for the subjects in experiments 2 through 5. Spectral analyses of quantitative changes in voltages have indicated that there are no conspicuous artifacts from current induction. For experiment 5, the 19-channel electrode cap employed in our more recent cognitive studies [65,66] was used, while the subjects sat between the same two large coils in which Mulligan and Persinger [40] had simulated some of the components of the geomagnetic correlates of power changes in QEEG [39,40]. However, the applied patterns included the digitized electroencephalographic activity from a person shown to affect other's EEG profiles and, when applied to melanoma cells, significantly slows their growth [64].

The Koren helmet contained 4 pairs (bilateral) of solenoids (modified reed switches with small iron cores) embedded within its lateral sides. The circuit was constructed to produce a weak-intensity magnetic field between a single pair of left and right-sided solenoids placed over the temporoparietal region. Although the solenoid clusters were situated over this region, the magnetic field, as measured by power meters sensitive to 10 nT, encompassed the entire cerebrum. The rapidly changing magnetic field strengths within the volume of the helmet occupied by the subject's head ranged between 1 and 5 μT (or between 10 and 50 mG). A small switch on the left and on the right side of the helmet allowed attenuation (by about 10%) of the strength of the field to be controlled.

For these experiments, the field was presented between each pair of the four sets of solenoids for 0.5 s such that one complete spatial (rotational) cycle was 2 s. The spatial configuration of solenoids was embedded in a helmet or a pair of small boxes where the spatial distribution of the solenoids was the same as those embedded in the helmet. One container was placed on each side of the forehead (bilaterally above the nasion) at the level of the frontal lobes and was held in place by a Velcro strip placed around the subject's head. This produced the strongest field within the medial, anterior prefrontal region. Experiments 1, 2, and 3 employed the traditional helmet, while experiment 4 involved the pair of containers.

The exposure coils for experiment 5 were two rectangular wrappings of wire around aluminum frames that have been described previously [41]. The cross sectional area of each was ~1 m^2. The field intensities were adjusted by computer software to be comparable with those of the helmet or containers, i.e., 10 to 50 mG in the area in which the subject sat. Specialized computer software that transformed a series of numbers between 0 and 255 to between −5 V and +5 V for the solenoids controlled a custom-constructed digital-to-analog converter. The values for each of the numbers between 0 and 255 determined the field pattern.

2.3. Procedure

All the subjects sat blindfolded within a comfortable chair within an acoustic chamber whose characteristics have been described [26,67]. The room was also a Faraday cage and reduced the local geomagnetic field to about half the usual intensity. Each of the subjects in experiments 2 through 5 had completed the informed consent procedures and was told that the nature of the study was to discern the effects of weak-intensity magnetic fields on relaxation. The subjects from the film crews also completed the informed consent but were aware of the nature of the experiment. Each subject was tested singly in a completely darkened chamber. In experiment 1, the subjects had completed the temporal lobe scale. The scores for the complex partial epileptic-like cluster and control cluster (to accommodate for yes responding) and the history of sensed presences after the experiment were completed for later comparison with the experiences reported during the field exposures.

For experiments 1 and 3, the sensed presence protocol was applied. During the first 30 min, the decreasing frequency-modulated pattern (849 points, the "Thomas pattern") with 3-ms point durations

was presented with a slight 10% increase over the right hemisphere compared with the left. The blindfold was removed, and the exit questionnaire was given (about 5 min were required). The items on the two-sided sheet are shown in Table 1. The blindfold was reapplied, the chamber lights were switched off, the door was again closed, and the increased frequency-modulated (289 points, "Burstx" pattern) field was presented as 3-ms point durations once every 3000 ms (3 s) for 30 min. This duration of exposure to the burst pattern produces analgesia comparable with 4 to 5 mg/kg of morphine in rats [30]. At the end of the exposure, the exit questionnaire was administered again.

For experiment 2, the burst-firing field (3-ms point durations presented once every 3 s) was presented with the 10% bias over the right or the left hemisphere for 20 min. For experiment 4, a pattern designed to affect dopamine bursting neurons was administered for 30 min. This magnetic field pattern was modeled after extracellular recordings of burst-firing dopamine neurons by Grace and Buney [68]. It consisted of 4 spikes (each 1-ms duration), with decreasing amplitude, separated by interspike intervals of 70 ms (Fig. 1). Magsound, a custom-generated program that utilized Scoptrax, was used to present the magnetic field from a 286 PC (one different from the one that operated the helmet).

The output was directed through a parallel port to a digital-to-analog converter where the wave file containing the dopamine pattern was converted into a series of voltages ranging from −5 to +5 V. These voltages in turn were transferred to the two boxes containing 4 reed switches that ultimately delivered the magnetic field across the cerebrum. The magnetic field apparatus was arranged such that each box was placed on either side of the medial frontal region.

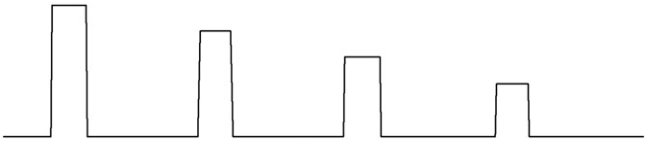

Fig. 1. Graphical representation of the derived dopamine-burst-firing pattern utilized in experiment 4.

The field strength ranged from 1 to 5 μT (the same range as the frequency-modulated patterns employed in the sensed presence protocol). In previous unpublished research, we had found that this pattern induced 'tingly' sensations similar to those experienced during the 'musical chill' phenomenon where individuals report 'shivers down the spine'.

For experiment 5, the frequency-modulated field that encourages the sensed presence was presented with point durations of either 1 ms, 3 ms, or 5 ms in counterbalanced order for 5 min each. In addition, the digitized pattern from the brain of a person with an exceptional ability to infer the cognitive states of others [69] and, when exposed to melanoma cells, slows their growth [64], was presented with 1-ms, 3-ms, and 5-ms point durations for 5 min each for a total of 30 min for the entire experiment.

2.4. EEG procedure

There were no QEEG measurements, only strip-chart recordings with a P79 Grass unit, for the film crew volunteers. The EEGs were interpreted qualitatively according to previous procedures [44]. Each person completed the exit questionnaire at the end of the first and second components of the sensed presence protocol. For the other four experiments, a Mitsar 201 system amplifier, using a sampling rate of 250 Hz within an input range of +/− 500 μV and 16-bit analog-to-digital conversion monitored the brain activity from each participant. An electrode cap (Electro-Cap International) with 19 AgCl electrodes, sited according to the 10-20 International Standard of Electrode placements, was placed onto the scalp for monopolar recordings (ear referenced). Impedance for all electrodes was maintained at less than 10 kΩ. Data collection and artifact correction for eye blinks were performed using WinEEG v2.82.

For experiment 2, on separate days, each participant received either a left (N = 4), a right (N = 4), or a sham (N = 3) hemispheric stimulation for 30 min. We reasoned that if the effect was robust (explaining about 40% of the variance), as demonstrated previously (and required for clinical efficacy [53]), this sample size was sufficient to be statistically significant at the $p < .01$ level. Three 30-second samples of data were extracted from each EEG record (representing times 0, 15, and 30 min). For experiment 3, data collection was continuous. The power measures for each of the classic bands delta (1–4 Hz), theta (4–7.5 Hz), low alpha (7.5–10.5 Hz), high alpha (10.5–13.5 Hz), low beta (13.5–20 Hz), high beta (20–30 Hz), and gamma (30–40 Hz) for the various sensors were extracted for each 15-minute interval. Coherence within the same frequency bands was also computed.

For experiment 4 that utilized the "chill pattern", a similar sampling was followed. For experiment 5, coherence between QEEG data from the two hemispheres was calculated by EEGLab package [70]. Specific coherence for T3–T4, T5–T6, T3–T6, and T5–T4 was completed for 4-s segments extracted at 0, 1, 2, 3, and 4 min after the initiation of various point durations (1, 3, and 5 ms). Each subject was exposed to six 5-min intervals of either the decelerating frequency-modulated pattern or the digitized pattern that had been extracted from the anomalous EEG configurations from the right temporoparietal region

Table 1
Items from the exit questionnaire employed over the last 20 years to discern within the experimental setting the frequency of various experiences known to be associated with complex partial epileptic-like experiences and the characteristics of the "parasitic consciousness" concept. For Side A, the ratings were 0 (never), 1 (at least once), and 2 (several times). For Side B, the ratings were yes or no.

	Side A
1	I felt dizzy or odd.
2	I felt the presence of someone or something.
3	There were tingling sensations.
4	I saw vivid visual images.
5	There were pleasant vibrations moving through my body.
6	I felt as if I had left my body or was detached from my body.
7	I heard an inner voice call my name.
8	I experienced anger.
9	I experienced sadness.
10	The experiences did not come from my own mind.
11	I heard a ticking sound.
12	There were odd smells.
13	I experienced fear or terror.
14	There were odd tastes in my mouth.
15	I felt as if I were somewhere else.
16	I experienced thoughts from my childhood.
17	The same idea kept occurring.
18	I felt as if I were spinning around.
19	There were images from a dream I've had.
20	The red light became brighter or darker.

	Side B
1	I developed a headache.
2	The visual experiences were primarily along the side of my eyes.
3	The visual experiences were primarily in the upper part of my eyes or visual field.
4	Visual images were primarily on the left side.
5	Visual images were primarily on the right side.
6	I felt sick.
7	Some of the experiences were meaningful, even emotional.
8	I felt something like sexual arousal.
9	Time passed quickly.
10	I have experienced many of the effects before.
11	I found the experience relaxing.
12	I have had some difficulty understanding the words in the questionnaire.
13	Please rate the overall experience (range −2, −1, 0, +1, +2).

of a person who displays a marked ability to infer the memories and intentions of others [69].

The digitized brain pattern when applied as a magnetic field to melanoma cells for 1 h per day for 5 days produced a marked reduction in growth [64]. The order of presentation, frequency-modulated versus EEG digitized pattern, and their respective three-point durations (1, 3, and 5 ms) were counterbalanced for each of the 6 subjects. During the 40-min exposure, to include pre- and post-baselines, QEEG data were collected continuously. The values were transported to SPSS PC for statistical analyses.

Source localization was completed using sLORETA software [71] on relative normalized data with a variance smoothing parameter equal to 0. The EEG segments were imported into MATLAB v.7 software where spectral analysis was performed using the *spectopo* function within the EEGLab toolbox [70]. Coherence analyses were completed using specialized scripts within the EEGLab platform. All spectral data were then imported into SPSS v.17 for further statistical analysis.

3. Results

3.1. Film crews

The incidences of sensed presence, out-of-body experience (OOBE), both types of experiences, and no experience for this sample of film crews are shown in Table 2. The patterns were qualitatively similar to the reports of university students who have been exposed to these fields [38]. The primary differences between the atheists/agnostics and participants who reported histories of near-death experiences were the post hoc attributions. The former group explained their experiences in neuroscientific terms, while the later group referred to mystical or spiritual sources, including deceased members of the family.

Qualitative assessments of the strip-chart EEG activity indicated that those who did not exhibit any of the key experiences (sensed presence or OOBE) displayed no alpha rhythms over the temporal regions, while those who reported the sensed presence (singly or in combination with OOBEs) showed progressively increased prevalence of alpha rhythms over the temporal lobes. On the basis of when the 14 participants who reported a sensed presence estimated the occurrences during the two separate 30-min exposures to the fields, visual inspection of the records indicated periods of either fast beta (25–30 Hz) activity over frontal regions or slowing alpha rhythms approaching the theta range over the temporal and frontal regions.

Algebraic summations indicated that these changes were primarily over the right hemisphere. The durations of these transients were not longer than 5 to 10 s and were similar to the occurrence of spontaneous sensed presences and paroxysmal activity in clinical settings with patients with histories of temporal lobe electrical lability [9] that intermittently emerge after significant mechanical impacts to the cerebrum without loss of consciousness.

Two-way analysis of variance with one within-subject level (slowing and accelerating frequency-modulated magnetic field periods) and one between-subjects level (sex) with respect to the report of a sensed presence revealed no statistically significant main effects. However, there was a statistically significant interaction [$F(1,26) = 6.12$, $p < .05$; $eta^2 = .20$]. Post hoc analysis indicated that this was due to more presences (about double the number) being reported by the women during the first exposures, while more presences were reported by the men during the second exposures. Additional analyses indicated that during the right hemisphere enhanced stimulation, the presences, if they occurred, were attributed to the left side (~85%) of the body space, while the shift to right side (~74%) occurred during the second phase, the bilateral stimulation.

Table 2
Frequencies of experiences for individuals affiliated with various film crews during the experimental elicitation of experiences similar to Hughlings Jackson's "parasitic consciousness".

	Frequency	Percent
No experience	8	25.8
Sensed presence	3	9.7
Out-of-body experience	9	29.0
Sensed presence and out-of-body experience	11	35.5
Total	31	100

The correlations between the CPESs and the incidence of sensed presences during the slowing and accelerating frequency-modulated fields were 0.42 ($p < .05$) and 0.62 ($p < .001$), respectively. For the control cluster, these values were −0.06 and −0.22, respectively and were not statistically significant ($p > .05$). There were no significant correlations between the participants' previous experiences of sensed presences (as inferred by the questionnaire data) and the report within the experiment for either exposure (−0.05 and 0.32, respectively).

The correlation between the ratios of complex partial epileptic-like signs to the control cluster (in order to control for simple affirmation or "yes" response profiles) and incidence of sensed presences was 0.57 ($p < .01$) for the slowing frequency modulation and 0.68 ($p < .001$) for the accelerating frequency field. The strength of the partial correlation between the CPES scores and presences during the first exposure was not significantly altered (0.57) when the shared variance associated with accelerating burst firing was controlled.

However, when the report of a presence associated with the slowing frequency modulation (the first component of the process) field was first removed, the correlation between incidence of sensed presences and the accelerating frequency modulation was eliminated (partial $r = .01$, $p > .05$). These results suggested that an interactive process occurring during the first component of the sensed presence protocol and the person's temporal lobe sensitivity (as inferred by the history of partial seizure-like experiences) was critical for the report of the sensed presences in the second component of the protocol.

3.2. Asymmetrical magnetic field stimulation and sLORETA patterns

There were no reports of sensed presences or OOBEs indicated on the exit questionnaire in this study. Four-way multivariate analyses of variance with three within-subject factors (time, lobe, and hemisphere) and one between-subjects hemisphere (magnetic field presentation over the left or the right hemisphere as well as a sham condition) were performed on spectral data for the various pairs of left/right hemispheric sensors within the delta, theta, low alpha, high alpha, low beta, high beta, and gamma frequency bands. Only the values for sensor positions T5 and T6 (left and right temporal

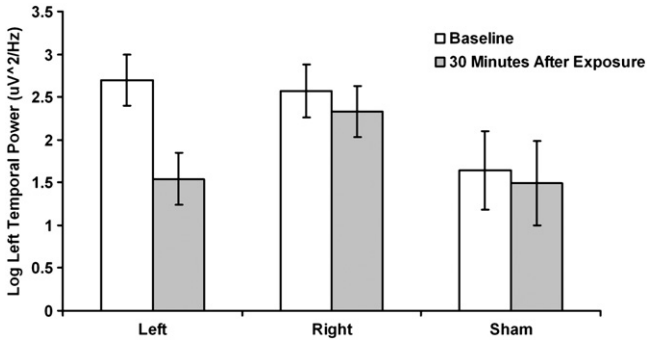

Fig. 2. Relative low beta (13–20 Hz) power within the left temporal lobe during the application of a burst-firing magnetic field. Individuals who received treatment exposure over the left temporal lobe showed a decrease in power after 30 min, whereas those who received right hemispheric or sham stimulation showed no significant change.

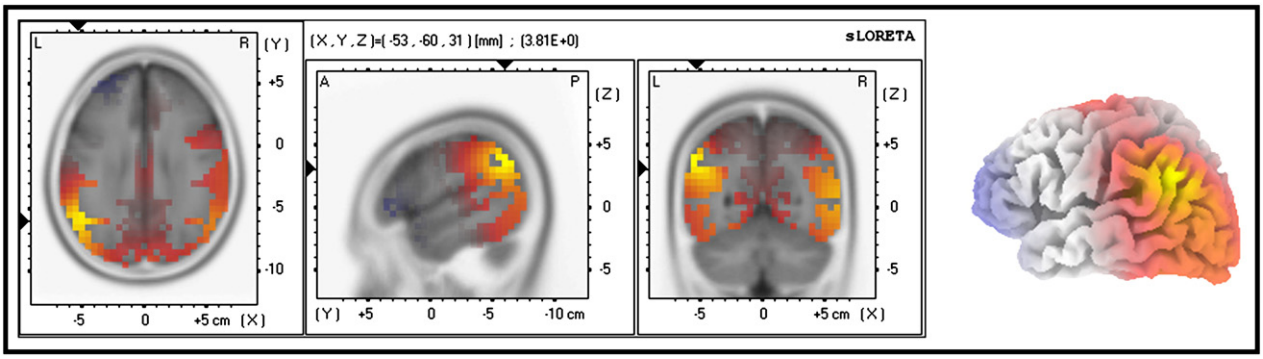

Fig. 3. Individuals who received application of a burst-firing magnetic field over the left temporoparietal area displayed a significant increase in delta activity over the left angular and supramarginal gyri compared with those who received the electromagnetic field over the right hemisphere.

lobes) within the low beta (14–20 Hz) frequency band demonstrated the predicted four-way interaction.

The analysis revealed a significant interaction ($F_{6,24} = 2.63$; $p = .04$; $eta^2 = .40$) between duration of measurement, lobe of measurement, hemisphere of measurement, and hemisphere of application. Post hoc analyses utilizing paired t-tests for the left and right side applications of the burst firing (once every 3 s) separately revealed that the source of the interaction was due to a decrease in left temporal (T5) power within the 14- to 20-Hz range during the last 10 min compared with baseline for the participants exposed to the magnetic field over the left hemisphere relative to those subjects exposed to the enhanced field over the right hemisphere or sham condition (Fig. 2).

Source localization was completed for the subjects who had received enhanced left hemispheric stimulation by comparing the appropriate values from those who received right hemispheric enhancement. The analysis demonstrated that the group who received left hemispheric stimulation displayed greater ($p < .05$) delta activity within the left temporoparietal area, specifically within the angular and supramarginal gyri (Fig. 3). Yellow indicates areas of highest power, while orange-red indicates lesser but significantly greater power than over the right homologous areas.

3.3. Sensed presence vs non-sensed presence brain profiles

Even with a small sample size, the differential patterns were obvious between the 4 subjects who reported the experience of a sensed presence when exposed to the specific magnetic field configuration compared with the 6 who were exposed to the same configuration but did not report a sensed presence. As can be seen in Fig. 4(top), the coherence of high alpha (10.5–13 Hz) power between the left and right temporal lobes increased after 5 min and continued for about 20 min within those who reported the sensed presence. During

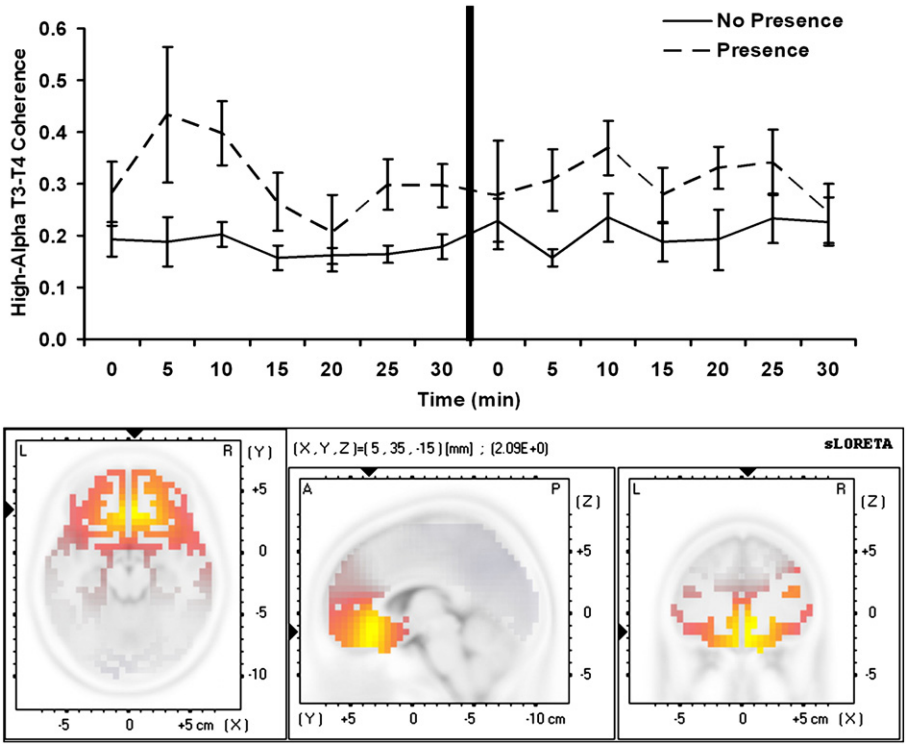

Fig. 4. (Top) Individuals who experienced a sensed presence displayed a significant increase in left–right temporal coherence within the high alpha (10–13 Hz) band 5 to 10 min after the initiation of a frequency-modulated electromagnetic field pattern (Thomas pulse). (Bottom) The increased coherence was accompanied by a concomitant increase in theta activity within the ventral portions of the temporal lobe.

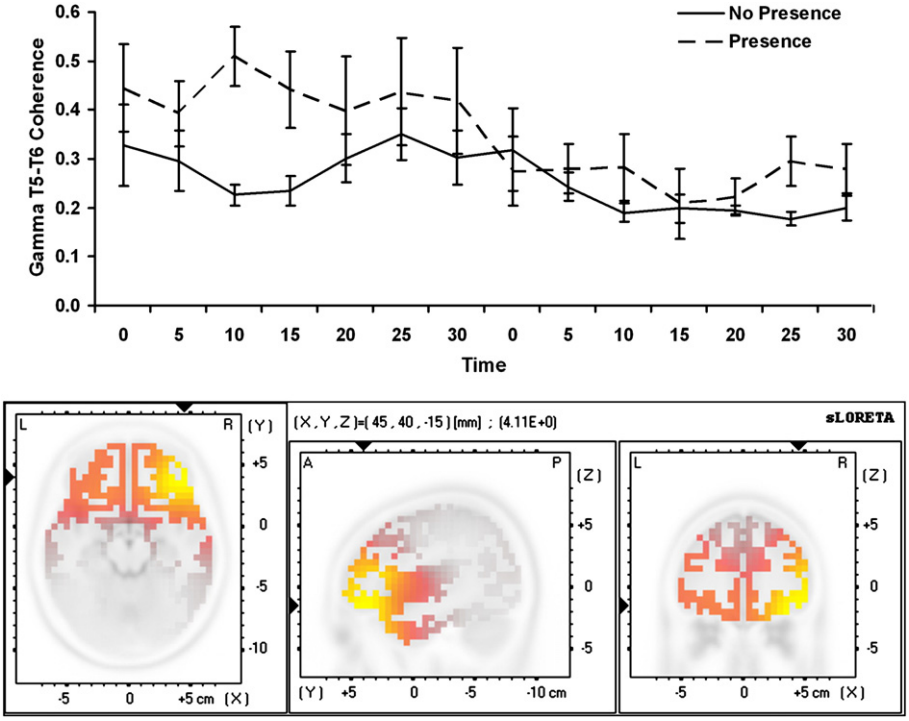

Fig. 5. (Top) There was a statistically significant increase in gamma-band (>35 Hz) bilateral coherence approximately 10–15 minutes after the initiation of the Thomas pattern. (Bottom) The increase was accompanied by an increase in gamma power within the right prefrontal region as well as the anterior portions of the temporal lobe.

this same period, there was increased theta power within the ventral regions of both prefrontal regions (Fig. 4(bottom)).

This initial peak in coherence power between the two temporal lobes (T3 and T4) within the alpha range was followed by an increased coherence in gamma activity about 10 min after the initiation of the field (5 min after the alpha coherence) within adjacent regions (T5 and T6) of the left and right temporal lobes (Fig. 5(top)). sLORETA analyses indicated that during the latter, there was a marked increase in gamma power within the right prefrontal and anterior portions of the temporal pole (Fig. 5(bottom)).

3.4. Chill inductions and brain activity patterns

The "chill and tingling" response by a specific and new pattern of magnetic field was observed. The analysis demonstrated that those who received the electromagnetic pattern designed to simulate "dopaminergic burst firing" reported significantly more tingles ($F_{1,9} = 6.48$; $p < .05$; $eta^2 = .42$) than those exposed to the sham field. In fact, not a single participant in the sham condition reported this experience.

To discern whether the field or simply sitting in the chamber influenced activation of the brain in any systematic way, source localization was completed on the data extracted from each raw record. The analysis indicated that there was a significant decrease ($p < .05$) in delta (1.5–4 Hz) activity within the posterior cingulate and a region encompassing the medial frontal gyrus (BA 11), the dorsal and ventral regions of the anterior cingulate (BA 32 and 24), and the ventromedial prefrontal cortices (BA 25) for individuals who did *not* receive a magnetic field, i.e., the sham field condition (Fig. 6). These areas were identified as regions of interest (ROIs), and activations within these regions were extracted for further analysis.

Relative scores from baseline at 10, 20, and 30 min of field exposure were computed on the sLORETA activation scores pertaining to the above mentioned regions-of-interest. These scores were subsequently entered into separate multilevel analysis of variance with one between-subjects factor (condition) and 3 within-subject factors (time, region-of-interest, and hemisphere) for the delta (1.5–4 Hz), theta (4–7.5 Hz), low alpha (7.5–10.5 Hz), high alpha (10.5–13.5 Hz), low beta (13.5–20 Hz), high beta (20–30 Hz), and gamma (30–40 Hz) bands.

The analysis demonstrated a significant condition by ROI interaction ($F_{3,27} = 3.10$; $p < .05$; partial $eta^2 = 26$). Post hoc analyses utilizing four separate one-way analyses of variance indicated that

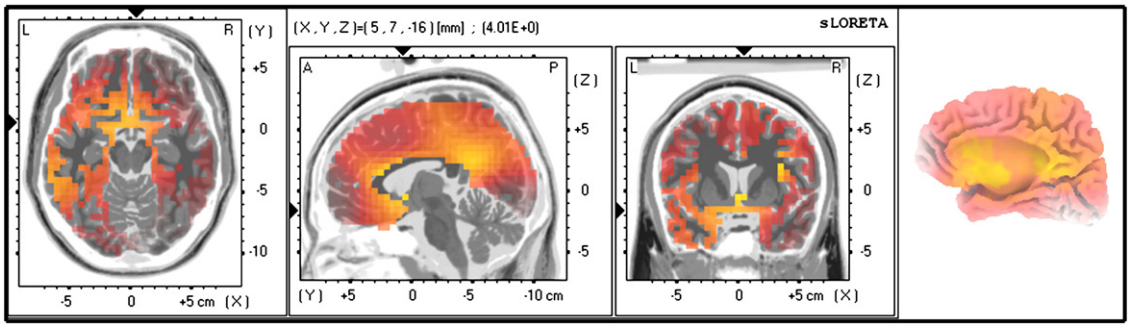

Fig. 6. Low alpha activation within the medial frontal gyrus was increased significantly upon exposure to the "dopaminergic"-patterned electromagnetic field.

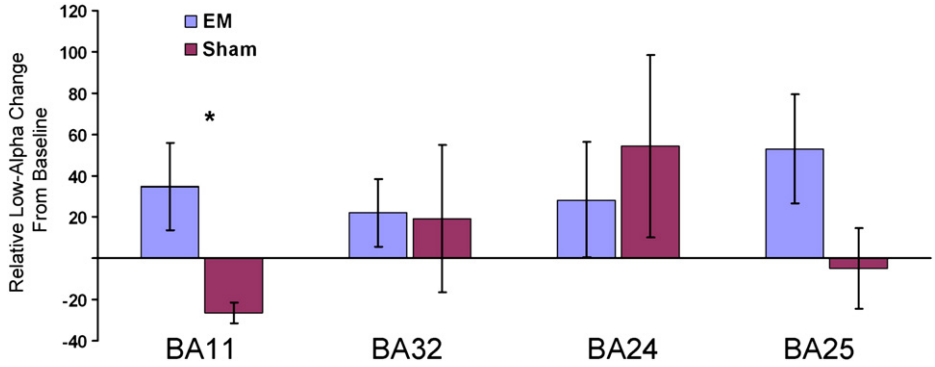

Fig. 7. Relative changes in low alpha activity within different inferred Brodmann areas (BA) according to sLORETA during the "dopaminergic" EM field. Vertical lines are SEMs.

individuals exposed to the "chill-generating" magnetic field displayed statistically significantly higher ($F_{1,9} = 6.75$; $p < .05$; $eta^2 = .43$) low alpha activation within the medial frontal gyrus (BA 11), whereas participants within the reference field condition showed a decrease (Fig. 7).

Because the current experiment did not allow us to assess brain activation at the exact time that the chill sensation was experienced, the relative scores at each time period were averaged together to produce a general activation score for each region-of-interest. Spearman rank-order correlations were then completed between these activation scores as well as the report of a tingly sensation. The analysis revealed that the experience of "vibrations" and "tingling" was positively correlated with activation scores within the medial frontal gyrus (rho = .81, $p = .002$) as well as the ventromedial prefrontal cortices (rho = .83, $p = .002$).

3.5. Whole body exposures

Separate MANOVAs with three levels (time, coherence, and condition) were completed for the seven frequency bands during whole body exposure to the same basic patterns as those applied through the head by the helmet. Within the delta band, there was a significant [$F(18,108) = 1.86$, $p < .05$; $eta^2 = .22$) three-way interaction between time, coherence, and condition. Post hoc analyses (Fig. 8) indicated that the primary source of the interaction was due to the increase in the relative change from baseline between T3 and T4 for coherence within the delta range after 2 min to 4 min of exposure compared with after 1 min of exposure for the 1-ms point durations but not for the 3- or 5-ms point durations. This was reflected as a statistically significant [$F(2,12) = 5.76$, $p < .05$, $eta^2 = 0.49$) main effect for overall left–right temporal lobe coherence within the low beta range for the 1-ms point durations compared with either the 3-ms or 5-ms point durations that explained almost half of the variance in interhemispheric coherence strength (Fig. 9).

What was particularly revealing was the differential effect upon power (μV^2/Hz) between the decelerating frequency-modulated and the anomalous digitized EEG pattern from the cerebrum of a person with unusual inferencing capacity [66]. As shown in Fig. 10, the importance of point duration is clear. Although 1-ms point durations facilitated coherence between the temporal lobes, the global power differential effect occurred for the 25–30 Hz band when the fields were presented with 3-ms point durations.

On the other hand, the differential effect of the two field patterns on the power within the alpha-2 band (10–13 Hz) involved cerebral area. Regardless of the point duration, there were marked elevations of alpha power over the parietal and occipital lobes (Fig. 11) during the presentations (5-min increments) of the digitized configuration of brain activity compared with the decelerating frequency-modulated pattern. The effect accommodated about 35% of the variance for power within this band over the 8 areas indicated.

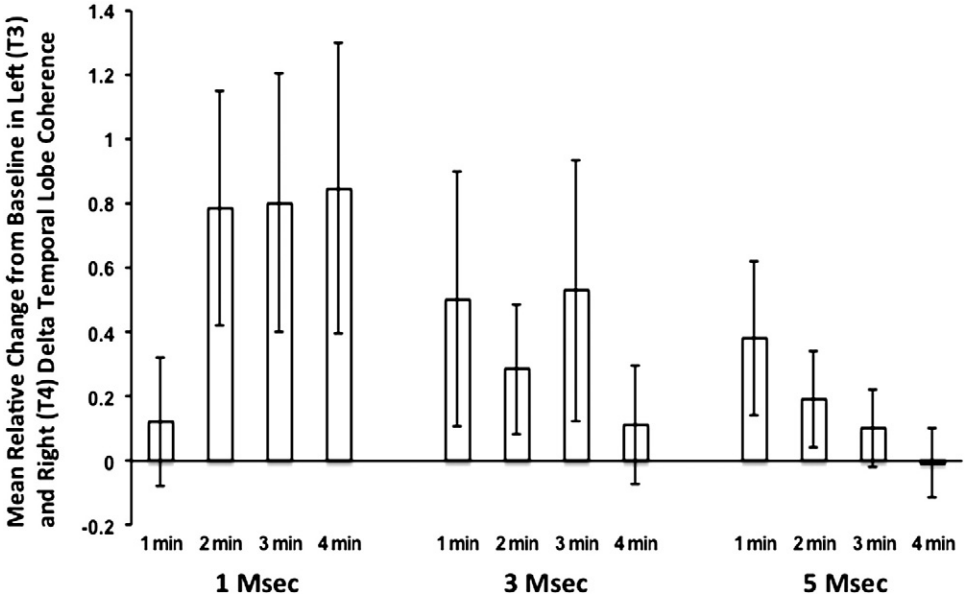

Fig. 8. Intertemporal lobe coherence within the delta range for the different point durations (1, 3, and 5 ms) of the effective pattern as a function of duration of exposure in minutes.

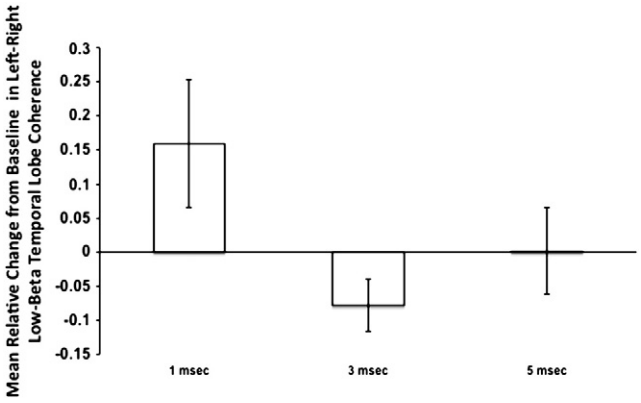

Fig. 9. Intertemporal lobe coherence (relative change from baseline during field presentation) within the 13- to 20-Hz EEG band for the effective pattern presented as 1-ms, 3-ms, or 5-ms point durations.

4. Discussion

The varying results of different research groups concerning the generalizability of inducing the experience of a "parasitic consciousness" or sensed presence and other exotic experiences similar to those reported by Hughlings Jackson through external application of weak, physiologically-patterned magnetic fields across the cerebral hemispheres might be analogous to the consequences of small difference in molecular structures that affect different receptor subtypes. Small changes in molecular configuration affect efficacy and can shift the reaction from maximum to minimum. The results of the present experiments suggest that there may be critical temporal parameters that must be accommodated in order for the cerebral conditions, crudely reflected as interhemispheric coherence, to promote the likelihood that subjects will experience (or report) variants of Hughlings Jackson's phenomena.

In the present study, the sensed presence was frequently reported during the same field parameters that have been applied for two decades to hundreds of volunteers and measured by dozens of experimenters [38]. The reported subjective experiences were specific to quantitative changes in brain activity and source (sLORETA) location and were congruent with the original explanations. The vectorial hemisphericity hypothesis [46] predicts that most sensed presence experiences are correlated with increased coherence between the left and the right hemisphere. The source of the intercalation originates within

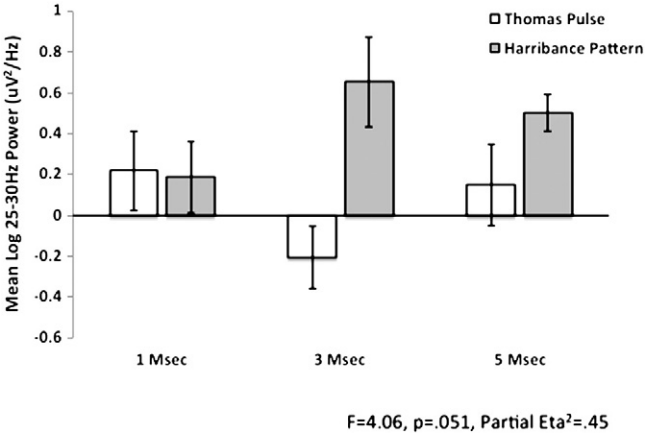

Fig. 10. Mean log (base 10) values of global cerebral power within the 25- to 30-Hz band for the same subjects exposed (in counterbalancing order) to either the Thomas (frequency-modulated) or digitized anomalous brain activity from a person who infers memories of others (Harribance configuration) as a function of the point duration of the presented magnetic fields. Vertical bars are SEMs.

the *right* temporal and (variably) frontal regions. The former effect may be direct or indirect because of diminished inhibitory influence from the coupled prefrontal region.

This would be consistent with the interpretation that the sensed presence is the experience of the right hemispheric equivalent of the left hemispheric sense of self. According to that hypothesis, like the classic mathematical matrices, there would be many hemispheric configurations that would promote these conditions. The dominant hemisphere would influence the perceived spatial location of the experience. The dominating hemisphere would also determine if the experience was affectively negative (perceived along the left side) or affectively positive (perceived along the right side, with auditory components) for most people.

The differential sensitivity within specific power intervals and areas of the right and left hemispheres to the applied magnetic fields would be predicted by the functional differences between the two hemispheres and the marked difference in cerebral cortical morphology. As indicated by Van Essen and Drury [72], only 4 of the major sulci of the more than 160 sulci and gyri that define the total cortical manifold share similarity between the two hemispheres. The differential sensitivity of the hemispheres to physiologically-patterned magnetic fields, as shown in experiment 2, can also be complicated by the *order* of the temporal patterns during the stimulation. Although enhanced application to the left hemisphere of the same burst-firing field that encourages the sensed presence when applied bilaterally after the right hemispheric stimulation was associated with altered power (whereas right enhanced hemispheric application of the same field did not produce this effect), nonsensed presences were reported.

The likelihood that the observed changes in cerebral activity were artifacts of induction from the applied field upon the instrumentation is minimal. First, the changes in EEG power and sLORETA patterns when the fields were activated and the presences were reported were cerebrally localized. Second, and most importantly, at least 5 to 10 min of continuous exposure was required before the sLORETA and coherence effects were observed.

We suspect that there are many different neuroanatomical pathways and cortical configurations that would converge to produce the sensed presence, each with their own unique characteristics. The phenomena would be similar to the multitude of pathways that mediate the amnesic syndrome through the dorsal hippocampal commissure as described by Gloor et al. [73]. Considering the complexity of the human brain, one would expect that a multitude of cerebral cortical patterns whose net vectorial solution is similar could produce the sensed presence. This value can be obtained from a large number of combinations in a manner similar to Wackermann's [74] approach.

As a group, the male participants from film crews over the years showed the enhancement during the second component of the presence protocol. The female participants showed more sensed presences during the first component. Over both components, there were equal numbers of sensed presences and out-of-body experiences for both the decreasing frequency-modulated and increasing frequency-modulated exposure components. We [51] have found that the components of the sensed presence display gender-specific characteristics that are congruent with the general patterns of cerebral sexual dimorphism. On average, young women display a shorter latency to sense or report these experiences compared young men.

One explanation is that the parietotemporal regions of the average female brain display more EEG coherence than the average male brain [75]. Hence, the first field component with the enhanced right hemispheric stimulation would have increased the likelihood of the "intrusive" experience. For the men, the initial right hemispheric stimulation was required before the bilateral application could facilitate the interaction.

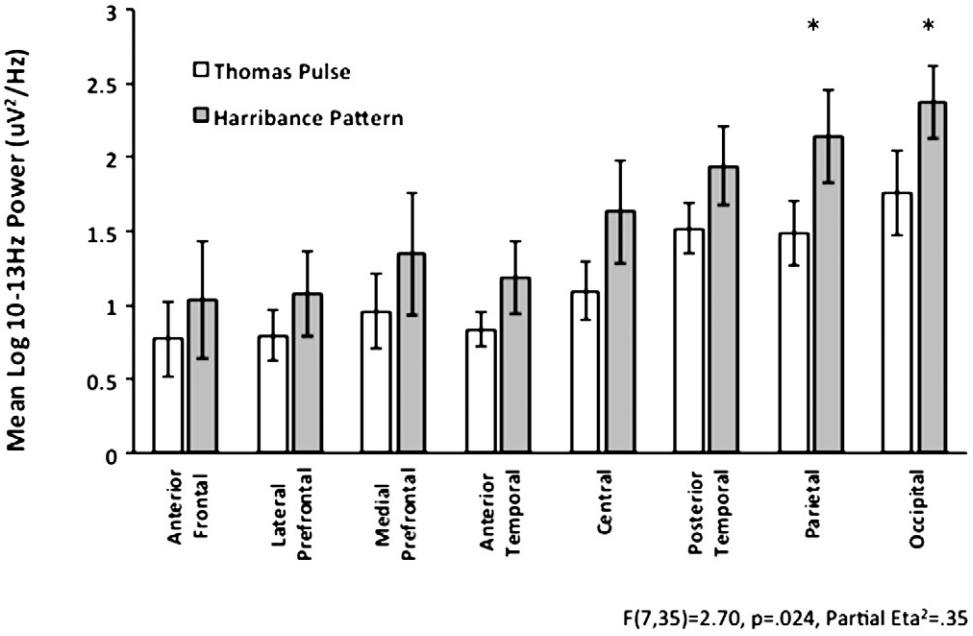

Fig. 11. Mean log (base 10) values of global cerebral power within the upper alpha band for the Thomas pulse (classically employed to induce the sensed presence) and the Harribance configuration (digitized pattern from an anomalous EEG) over various regions of healthy subjects' scalps. Vertical bars are SEMs; * indicates statistical significance.

In addition to expectation factors, most of these participants in the film crew study were circadian-shifted or mildly sleep-deprived because of traveling. We have found that elevated "stress" as well as circadian shifts enhance the sensitivity and decrease the latency to respond to weak magnetic fields, assuming that they did not enter Stage 2 ("sleep spindles") too quickly. If the subject "falls asleep", there is no reporting. The neurochemistry associated with "stress", particularly elevated corticotrophin releasing factor (CRF) and cortisol, seems to enhance the intensity of these experiences if they are occurring.

The subjective experiences of the film participants were congruent with hemispheric cortical function. Those who received the right hemispheric-enhanced frequency-modulated pattern reported more presences on the left side of the body. During the bilateral presentation, the experiences were more frequently attributed to the right side of the body and were judged as more positive and tranquil. As would be expected, the atheists and agnostics attributed the experiences to their brains, while those with histories of near-death or mystical experiences employed explanations congruent with their beliefs even though they knew that they were sitting in a laboratory.

The importance of the timing of the intrinsic voltage components (point durations) that compose the field patterns to which the person was exposed has been shown for cells, rodents, and human beings. We suggest that future applications of weak complex magnetic fields to the cerebral cortices, in order to evoke either the sensed presence (or shadow person) or the out-of-body experiences, carefully control the timing and electronic details of the applied field with the care and precision of administrating the precise target molecule for psychopharmacology.

The mechanisms by which weak applied magnetic fields influence cerebral activity have shifted from Faradic induction and, hence, forces, to the concepts more compatible with quantum energy [76]. The increased energy "storage" [47,77] from an applied 10-mG (1 μT) magnetic field within the cerebral cortical volume would be in the order of 10^{-9} J. If each action potential is associated with energies of ~10^{-20} J [76], then the applied energy would be equivalent to about 10^{10} neurons firing at about 10 Hz. This number of neurons is within the critical mass associated with "conscious awareness".

Many individuals who are troubled by "spontaneous" occurrences of the sensed presence report that experiencing these phenomena within a supportive and clinical environment is beneficial. When these patients are exposed to the types of fields described in this study and the evoked "frightening" experience of the "parasitic consciousness" occurs, the person can be taught other attributions for the causes. The anxiolytic consequences of these "controlled" or alternatively attributed experiences have positive influence upon the person's cognitive state as well as his or her adaptation.

The occurrence of these "spontaneous" experiences may be more prevalent than recognized [78,79]. Persinger and Koren [80] reported the case of a young woman who had a history of an early right prefrontal brain injury. She frequently experienced what she attributed to an "entity" that sexually stimulated her and appeared as an apparition. Most of the experiences, including the feeling of the outline of a "baby", were over the left upper back of the body. Although the family preferred a more religious interpretation, the source of the stimulation was traced to a defective electronic clock that she placed near her skull when she slept. The clock generated a field with an almost identical complex temporal pattern and intensity as the frequency-modulated pulse employed in the laboratory that generated the effects in the present study.

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